

Occupational dermatitis in shoemakers

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In an epidemiological study of occupational dermatitis in 5 different shoe factories, 246 workers were interviewed, examined and patch tested using standard and occupational patch test series. The prevalence of occupational contact dermatitis was 14.6% (36/246): 8.1% (20/246) irritant contact dermatitis (OICD) and 6.5% (16/246) allergic contact dermatitis (OACD). Among the latter, the most common occupational allergens were p-tert-butylphenol-formaldehyde resin and mercaptobenzothiazole. 6% (15/246) presented with hyperkeratosis of the fingertips, while 3.2% (8/246) reported pruritus sine materia (PSM) present only during working hours. 2 workers presented with vitiligo-like leukodermic patches on the backs of their hands and on their forearms. Some jobs were more frequently associated with skin complaints. In the assembly department, OACD was most frequent (11.4%), attributed to contact with adhesives and, to a lesser degree, with rubber and leather. OICD caused by contact with the solvents contained in adhesives and varnishes was most frequent in the assembly and trimming departments (17.1% and 15.6%, respectively). PSM, probably caused by the dust present in the working environment was reported by 33.3% of the workers in the sole-cutting and scraping departments. Hyperkeratosis of the fingertips, as a reaction to the continuous trauma of leather on the skin, was observed most frequently (41.6%) in the sole-cutting department.)

Key words: occupational; allergic contact dermatitis; irritant contact dermatitis; solvents; adhesives; rubber; leather; p-tert-butylphenol-formaldehyde resin; epoxy resin; mercaptobenzothiazole; diphenylmethane diisocyanate; chloroacetamide; p-tert-butylphenol. © Munksgaard, 1996.

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The shoe manufacturing industry, especially at craftsman level, exposes its workers to contact with an extensive range of substances that can produce irritant or allergic contact dermatitis. The irritant activity of adhesives and solvents used in the production cycle and the sensitizing activity of allergens contained in adhesives, in skins, in rubber and in dyes is well-known (1-5).

The lack of data on the epidemiological aspects of occupational dermatitis in the shoe manufacturing industry justifies the aims of our study: evaluation of the prevalence of occupational dermatitis in this occupational category, analysis of the possible sources of sensitization to which such subjects are exposed, the allergens most frequently responsible and the clinical relevance of the positive reactions to the patch tests.

Materials and Methods

Between 1992 and 1994, 5 shoe manufacturers in the Emilia-Romagna region were studied. These

factories produce shoes mainly from natural skins, with part of the work, cutting, sole-cutting, edging, assembly, finishing and trimming, being carried out by hand (Fig. 1). A total of 246 workers (201 female and 45 male), aged from 17 to 59 (mean 38 years) and with duration of employment ranging from 1 month to 34 years (mean 16 years), work in these factories. In order to make the series as uniform as possible as regards risk factors, only those shoe factories that used similar materials and technology were included in the study. For the same reason, due to the different levels of exposure of the workers to the materials being used, they were divided according to their job (Table 1).

Clinical records were obtained for all subjects in order to document any current or previous contact dermatitis and to determine occupational and non-occupational risk factors.

All the workers, with or without current or previous skin disorders, were examined on their work premises and underwent patch tests with a series of 77 allergens (Table 2), supplied mostly by Firma

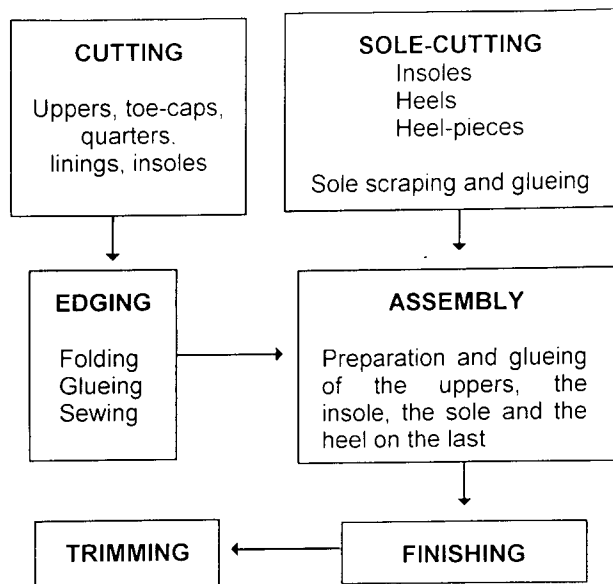


Fig. 1. Shoe manufacture diagram.

Table 1. Distribution of the series considered in relation to the job carried out

Department	No. employees
cutting	27
edging	48
assembly	70
sole-cutting	24
finishing	45
trimming	32
total	246

Diagent (Italy). The allergens included a European standard series and an occupational series, devised on the basis of data in the literature (1-5) and on a survey carried out in the shoe factories in question. In all cases, the allergologic study was completed by patch tests with a series of materials used in the sector and tested, some as skins and solid resins, as is, and others as adhesives appropriately dispersed in pet. (3). The patch tests were applied to the back by means of patch test chambers (van der Bend, the Netherlands), removed after 2 days and read at 3 and 4 days. The technique used and the method of interpreting the patch test results are those recommended by the ICDRG. The occupational nature of the contact dermatitis was defined on the basis of clinical-allergological criteria and on the positivity of a stop-start test of the working activity.

Results

Skin reactions

Skin reactions of various kinds correlated with the working activity were found in 61 out of 246

workers (24.7%). These were mainly cases of contact dermatitis on the hands, more rarely spreading also to the forearms and to other areas. The prevalence of this dermatitis was equal to 14.6% (36/246); 8.1% of these cases (20/246) were irritant-type dermatitis and 6.5% (16/246) allergic dermatitis. The intensity of these disorders was generally slight and did not prevent the workers from continuing their working activity. Localized itching of the uncovered areas while carrying out their work was reported by 3.2% (8/246) of the workers, disappearing spontaneously after work finished for the day. 6% (15/246) presented with hyperkeratosis on the palms of the hands with elective localization on the fingertips. 2 workers presented with vitiligo-like leukodermic patches on the backs of the hands and on the forearms.

Jobs and skin reactions

Some jobs more than others were shown to be associated with occupational dermatitis (Table 3). In particular, in the assembly department, occupational allergic contact dermatitis (OACD) was more frequent (11.4%). In the assembly and trimming departments, occupational irritant contact dermatitis (OICD) was observed more frequently (17.1% and 15.6%, respectively). Pruritus sine materia (i.e., itching without visible dermatitis) was reported by 33.3% of the workers in the sole cutting and scraping department. Hyperkeratosis of the fingertips was observed most frequently (41.6%) in the sole cutting department. 2 cases of leukoderma were reported in the assembly department.

Contact sensitization

In 16 workers with OACD (12 F, 4 M), the patch tests showed clinically significant positivity to 1 (7 cases) or more allergens (9 cases), with a total of 32 positive patch tests (Table 4). The working materials that were most frequently the cause of OACD proved to be neoprene-based adhesives, due to the presence of p-tert-butylphenol-formaldehyde resins (PTBP-F-R) and dodecylmercaptan; polyurethane-based adhesives, due to the presence of triethylenediamine and diphenylmethane diisocyanate (MDI); epoxy-resin-based adhesives, due to the presence of epoxy resin (oligomer), phenylglycidyl ether and ethylenediamine dihydrochloride; and rubber-based adhesives, with colophony, diphenylguanidine and mercaptobenzothiazole (MBT) as sensitizers. Less important from this point of view were solid rubber, with tetramethylthiuram disulfide (TMTD) and MBT as sensitizers, while no cases were observed of OACD

Table 2. Allergens used for the patch tests distributed according to the groups of substances used in the working process

European standard series			
<i>Preservatives</i>			
m-cresol	2%	<i>Epoxy resins and epoxy resin cements</i>	
phenylmercuric nitrate	0.01% aq.	epoxy resin*	1%
o-phenylphenol	1%	bisphenol A	0.5%
chloroacetamide	0.2%	epichlorohydrin	0.1% eth.
		phenyl glycidyl ether	0.25%
		allyl glycidyl ether	0.25%
		phthalic anhydride	1%
<i>Decoration</i>		maleic anhydride	1% eth.
nickel sulfate*	5%	ethylenediamine dihydrochloride*	1%
<i>Dyes</i>			
p-aminoazobenzene	0.25%	<i>Rubber and rubber cements</i>	
Bismark brown R (C.I.21010)	1%	carba mix*	3%
paraphenylenediamine*	1%	1,3 diphenylguanidine	1%
aniline	1%		0.5%
Disperse Yellow 3 (C.I. 11855)	1%	diaminodiphenylmethane	
Disperse Red 1 (C.I. 11110)	1%	dioctyl phthalate	2%
nigrosine base**	10%	dibutyl phthalate	5%
fuchsin**	1% aq.	mercaptobenzothiazole	1%
pyrocatechol	2%	mercapto mix*	2%
		isopropylaminodiphenylamine	0.1%
		tetramethylthiuram disulfide	1%
<i>Leather tanning agents</i>		thiuram mix*	1%
formaldehyde*	1% aq.	colophony*	20%
glutaraldehyde	0.5% aq.		
potassium dichromate*	0.5%	<i>Acrylic resins</i>	
natural tannin (Crown)	1%	methyl acrylate	1%
		ethyl acrylate	1%
<i>Neoprene and neoprene cements</i>		butyl acrylate	1%
dodecyl mercaptan	0.1%	methyl methacrylate	5%
ethylbutylthiourea**	1%	butyl methacrylate	2%
diphenylthiourea	2%	benzoyl peroxide	2%
diethylthiourea	1%	hydrazine	1%
para-tert-butylphenol	2%	resorcinol	1%
para-tert-butylphenol-formaldehyde resin*	1%	pyrogallol	1%
		tricresyl-phosphate	2%
		triphenyl-phosphate	5%
<i>Polyurethane and polyurethane cements</i>			
triethylenediamine	1%	<i>Other substances</i>	
methylamine hydrochloride	0.1%	nitrocellulose resin**	30%
toluene diisocyanate	0.1%		acet./tol.(1:1)
diphenylmethane diisocyanate**	2%	carnauba wax**	10%
triphenylmethane triisocyanate**	2%	beeswax**	10%
		turpentine	20%
		linseed oil**	as is
		palm oil**	as is

All allergens were tested in pet. unless otherwise indicated. Aq.=water; eth.=ethanol; acet.=acetone; tol.=toluol. * Allergens present in the European standard series. ** Allergens prepared by us (refs. (1, 3, 11, 12) were useful for this preparation).

Table 3. Prevalence of occupational skin reactions in shoe factories according to job

Job	No. workers	OACD	OICD	PSM	Hyperkeratosis	Leukoderma
cutting	27	1/27 (7.4%)	—	—	5/27 (18.5%)	—
edging	48	3/48 (6.2%)	3/48 (6.2%)	—	—	—
assembly	70	8/70 (11.4%)	12/70 (17.1%)	—	—	2/70 (2.8%)
sole-cutting	24	—	—	8/24 (33.3%)	10/24 (41.6%)	—
finishing	45	2/45 (4.4%)	—	—	—	—
trimming	32	2/32 (6.2%)	5/32 (15.6%)	—	—	—
total	246	16/246 (6.5%)	20/246 (8.1%)	8/246 (3.2%)	15/246 (6%)	2/246 (0.8%)

OACD: occupational allergic contact dermatitis; OICD: occupational irritant contact dermatitis; PSM: pruritus sine materia.

Table 4. Results of patch tests: positive reactions

Substances	OACD	NOACD	PSM	NAD	NSR
Bismark brown R	1	—	—	—	—
carba mix	1	—	—	1*	—
chloroacetamide	1	—	—	—	—
colophony	1	—	1	—	—
4,4'-diaminodiphenylmethane	1	3	—	—	1
1,3-diphenylguanidine	1	—	—	—	—
diphenylmethane-4,4'-diisocyanate	2	—	—	—	—
dodecyl mercaptan	1	—	—	—	1
epoxy resin	2	—	—	—	—
ethylenediamine dihydrochloride	1	—	—	—	—
formaldehyde	—	—	—	—	2
mercaptobenzothiazole	3	—	—	—	—
mercapto mix	1	—	—	—	—
neomycin	—	—	—	—	4
nickel sulfate	1	6	—	—	—
p-phenylenediamine	1	2	—	—	1
p-tert-butylphenol-formaldehyde resin	5	—	—	—	—
phenyl glycidyl ether	1	—	—	—	—
phenylmercuric nitrate	1	—	—	—	—
potassium dichromate	2	—	—	—	—
tetramethylthiuram disulfide	2	—	—	—	—
thiuram mix	2	—	—	—	—
triethylenediamine	1	—	—	—	—

OACD: occupational allergic contact dermatitis; NOACD: non-occupational allergic contact dermatitis; PSM: pruritus sine materia; NAD: nonallergic dermatitis; NSR: no skin reaction. * Psoriasis.

caused by solid polyurethane and acrylic resins, occasionally used in the production cycle. Last were skins, with potassium dichromate, chloroacetamide and phenylmercuric nitrate as sensitizers, and varnishes, with Bismarck brown R. In such cases, patch tests with some of the materials used in production (adhesives, skins, rubber and resins) confirmed the positivity found with individual allergens. The period between start of exposure and onset of the OACD was less than 1 year in 13 cases and more than 1 year in the other 3 cases. In 7 asymptomatic workers, the patch tests showed positivity to 1 or more allergens, some of which were specific to the working activity. 8 subjects were affected by non-occupational allergic contact dermatitis (NOACD). 16 workers (6.5%) had a personal history of atopy: 3 of these (18.7%) were affected by OACD and 5 (31.2%) by OICD.

Discussion

The majority of cases of OICD, observed most frequently in the assembly and trimming departments, could be attributed to the use of solvents contained in adhesives and varnishes. The most commonly used adhesives in the assembly department contained an organic-solvent-based volatile fraction, together with a solid fraction consisting of natural rubbers, neoprene and synthetic resins. These organic solvents included n-hexane or benzene homologues (toluene, xylene). In the trim-

ming and finishing departments solvents, polishing emulsions and nitrocellulose varnishes are used for touching-up the finished product. All these operations are almost always carried out manually, and generally without any protective measures. OACD was mainly due, in the cases examined, to contact with adhesives and, to a lesser extent, with rubber and with skins. The OACD was localized mainly on the hands, often with the characteristics of OICD with which it was often associated. As far as localization was concerned, the OACD caused by adhesives involved mainly the sides and tips of the first 3 fingers holding the glue brush, at times involving the backs of the hands. More rarely the forearms were affected (2 cases) and exceptionally the face (1 case).

Some allergens proved more likely than others to be capable of causing OACD: PTBP-F-R, MBT, potassium dichromate, epoxy resin, MDI and TMTD. PTBP-F-R, widely used in neoprene adhesives in the shoe manufacturing industry, frequently cause OACD (6-9): in most cases, such sensitization is due to intermediate compounds present in the unpolymerized product, such as polyphenolalcohols and linear structure polycondensates (7), while the 2 basic components, formaldehyde and PTBP, hardly ever seem to be the cause. Patch tests with these 2 substances are often negative in subjects with sensitization to PTBP-F-R (6, 8). The absence of reactions to patch tests with formaldehyde and with PTBP found in our

workers with sensitization to PTBP-F-R is in agreement with these data.

In 2 workers affected by OACD, we found positive patch tests to epoxy resin (prepolymer m.w. 464-500) present in some adhesives used for glueing the toe-caps and quarters. In one of these cases, we observed simultaneous sensitization to phenylglycidyl ether, a substance present in the adhesive as a thinner. The possibility of cross-reactions between glycidyl ethers and epoxy oligomers has been reported due to the presence of a terminal epoxy group in both (10). Sensitization to bisphenol A was not found in these cases, in agreement with the data reported in the literature (8).

In 2 workers with OACD from polyurethane adhesive (mostly elastomer-soluble-based), sensitization to diphenylmethane diisocyanate (MDI) contained in a 2-component polyurethane adhesive was detected. 1 of the 2 workers reacted simultaneously to both MDI and diaminodiphenylmethane (MDA). A structural similarity or cross-allergy between MDI and MDA has been considered as an explanation for simultaneous reactions to the 2 chemicals (11, 12). The other one reacted to MDI but not to MDA, regardless of exposure to both chemicals. Independent sensitization to MDA and MDI has, in fact, already been reported (12). In spite of the recognized sensitizing power of MDI (13), there are no cases in the literature of ACD caused by this substance either in those working in the shoe manufacturing industry or in those who wear shoes.

After adhesives, solid rubber proved to be the most frequent cause of OACD. The rubber accelerators, MBT and TMTD, head the list of most frequent causes in our study. 2 workers reacted to both MBT and TMTD, which, as rubber accelerators, are the most frequent causes of shoe contact dermatitis (2).

Among leather preservatives, phenylmercuric nitrate and chloroacetamide each caused 1 case of OACD; no case of OACD relative to these 2 substances has been described in footwear industry workers, and only 1 case of shoe contact dermatitis from chloroacetamide (14).

Among the tanning agents, only chrome was positive on patch testing, in spite of the use of skins treated with other tanning agents with well-known allergenic activity. 2 workers were positive (+++) to a patch test with formaldehyde, but were unaffected by handling leather previously tanned with this substance. The absence of skin lesions could be due to strong adhesion of the substance to the leather, preventing its release and consequent contact with the skin (2, 4).

The dyes contained in shoes rarely cause sensitization, due to strong adhesion of the dye to the

leather, reducing the sensitizing power to a minimum (2). In our experience, no sensitization was observed to dyes in the cutting, assembly and edging departments, in which the coloured leather is handled. 1 case of OACD from Bismark brown R was, on the other hand, observed in the trimming department, where this dye was used for touching-up the finished product. Sensitization to paraphenyldiamine observed in 1 worker could be merely the result of a cross-reaction of this substance with MDA, to which the worker proved intensely sensitive; paraphenyldiamine, on the other hand, was not contained in any of the products used in that shoe factory.

A personal history of atopy recurs frequently in subjects with OACD and above all with OICD. In all 3 subjects with atopy and OACD, there was an isolated sensitization to PTBP-F-R. The association of contact sensitization to this chemical with atopy has been reported before (15). Considering the particular susceptibility of the skin to irritants in atopic subjects, we believe that the atopy factor constitutes an important predisposing condition for the development of OICD in shoe factory workers in whom exposure to irritants is important.

Vitiligo-like leukodermic lesions were observed on the hands of 2 workers exposed for long periods to contact with PTBP-based adhesives, whose depigmenting activity is well-known (16, 17). This was diagnosed as occupational chemical leukoderma on the basis of the occupational risk, the negative family and personal history of idiopathic vitiligo, the exclusive localization of the lesions to the areas of contact and the absence of other conditions (thyrotoxicosis, Addison's disease, pernicious anemia) associated with the idiopathic form. Such a diagnosis can, in general, only be presumptive, there being no precise clinical or histological criteria to differentiate chemical leukoderma from idiopathic vitiligo and from other forms of leukoderma (17); the lesions in the 2 workers were not accompanied by contact sensitization to PTBP, in agreement with other observations (17).

8 workers employed in the sole cutting and scraping departments presented with pruritus sine materia in the uncovered areas, which disappeared spontaneously at the end of their working shift. This symptom was probably caused by the irritant action of the dust in the working environment. 7 of these workers were patch-test-negative and 1 patch-test-positive (+) to colophony. This positivity had no clinical significance.

Many of the workers in the upper and sole cutting departments presented with hyperkeratosis with scaling of the fingertips, as a reaction to the continuous trauma of the leather on the skin; these

lesions represent true occupational stigmata in workers in the shoe manufacturing industry, especially in those who still work at a craftsman level (18).

In conclusion, the data collected at the end of the study indicate a high prevalence of occupational dermatitis in shoe manufacturing workers with respect to other occupations (19), and prove the usefulness of continuous monitoring of the epidemiological and etiological aspects of these disorders. This will help in setting up correct measures of prevention, both individual and general, through personnel selection, occupational training, improvement in working conditions and use of adequate means of protection.

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